CLAIMS

What is claimed is:

1. A method of modifying an electrochemical processing chamber from a first configuration for treating a first workpiece to a second configuration for treating a different second workpiece, the electrochemical processing chamber initially comprising a reaction vessel having a plurality of electrodes positioned in electrically separate electrode compartments and a first virtual electrode unit defining a first set of virtual electrodes having predefined relative positions adapted for treating the first workpiece, each of the virtual electrodes being in fluid communication with one of the electrode compartments, the method comprising:

providing a second virtual electrode unit defining a second set of virtual electrodes having predetermined relative positions adapted for treating the second workpiece, the relative positions of the virtual electrodes in the first set differing from the relative positions of the virtual electrodes in the second set; and

replacing the first virtual electrode unit with the second virtual electrode unit, thereby modifying an effective electric field of the electrochemical processing chamber for treatment of the second workpiece without necessitating modification of the electrodes.

2. The method of claim 1 wherein the electrode compartments are defined by a first plurality of walls which are coupled to the first virtual electrode unit, the first plurality of walls and the first virtual electrode unit together defining a first field shaping unit, replacing the first virtual electrode unit with the second virtual electrode unit comprising removing the first field shaping unit as a unit.

3. The method of claim 2 wherein the second virtual electrode unit is coupled to a second plurality of walls, the second plurality of walls and the second virtual electrode unit together defining a second field shaping unit, relative positions of the walls in the second field shaping unit being the same as relative positions of the walls in the first field shaping unit, replacing the first virtual electrode unit with the second virtual electrode unit further comprising, after removing the first field shaping unit, placing the second field shaping unit in the reaction vessel as a unit such that the walls of the second field shaping unit are positioned in the same locations formerly occupied by walls of the first field shaping unit.

4. The method of claim 1 wherein replacing the first virtual electrode unit with the second virtual electrode unit comprises removing the first virtual electrode unit and, thereafter, installing the second virtual electrode unit in its place.

5. The method of claim 1 further comprising treating the first workpiece with the electrochemical processing chamber prior to replacing the first virtual electrode unit with the second virtual electrode unit.

6. The method of claim 1 further comprising treating the second workpiece with the electrochemical processing chamber after replacing the first virtual electrode unit with the second virtual electrode unit.

7. The method of claim 1 wherein the reaction vessel includes a flow distributor having a separate fluid conduit in fluid communication with each of the electrode compartments and a separate annular recess for releasably receiving a lower edge of each wall, replacing the first virtual

electrode unit with the second virtual electrode unit comprising removing the walls of the first partition from the annular recesses of the distributor.

8. The method of claim 7 wherein replacing the first virtual electrode unit with the second virtual electrode unit further comprises inserting a lower edge of each of the walls of the second virtual electrode unit in one of the annular recesses in the flow distributor.

9. The method of claim 1 wherein the electrochemical processing chamber initially includes a first contact assembly adapted to support the first workpiece in a predetermined position with respect to the first set of virtual electrodes, the method further comprising:

providing a second contact assembly adapted to support the second workpiece; and

replacing the first contact assembly with the second contact assembly.

10. The method of claim 9 further comprising supporting the second workpiece with the second contact assembly and applying an electrical potential to the electrodes.

11. A method of treating a first workpiece and a different second workpiece in an electrochemical processing chamber, comprising:

providing an electrochemical processing chamber comprising a reaction vessel having a plurality of electrodes positioned in electrically separate electrode compartments and a first virtual electrode unit defining a first set of virtual electrodes having predefined relative positions adapted for treating the first workpiece, each of the virtual electrodes being in fluid communication with one of the electrode compartments;

providing a second virtual electrode unit defining a second set of virtual electrodes having predetermined relative positions adapted for treating the second workpiece, the relative positions of the virtual electrodes in the first set differing from the relative positions of the virtual electrodes in the second set;

treating the first workpiece by applying an electrical potential to the electrodes;

thereafter, replacing the first virtual electrode unit with the second virtual electrode unit, thereby modifying an effective electric field of the electrochemical processing chamber for treatment of the second workpiece without necessitating modification of the electrodes; and

thereafter, treating the second workpiece by applying an electrical potential to the electrodes.

12. A method of treating a first workpiece and a different second workpiece in an electrochemical processing chamber, comprising:

providing an electrochemical processing chamber comprising a first contact assembly, a reaction vessel, an electrode received in an interior of the reaction vessel, and a first virtual electrode unit defining a first virtual electrode in fluid communication with the electrode;

providing a second contact assembly and a second virtual electrode unit defining a second virtual electrode;

supporting the first workpiece with the first contact assembly at a predetermined position with respect to the first virtual electrode;

treating the first workpiece by applying an electrical potential to the electrode;

thereafter, replacing the first virtual electrode unit with the second virtual electrode unit, thereby modifying an effective electric field of the electrochemical processing chamber for treatment of the second workpiece without necessitating modification of the electrodes;

supporting the second workpiece with the second contact assembly at a predetermined position with respect to the second virtual electrode; and

thereafter, treating the second workpiece by applying an electrical potential to the electrode.

13. A method of effectuating electrochemical treatment of a first workpiece and a different second workpiece, comprising:

providing an initial electrochemical processing chamber and a second virtual electrode unit,

the initial electrochemical processing chamber comprising a reaction vessel having a plurality of electrodes positioned in electrically separate electrode compartments and a first virtual electrode unit defining a first set of virtual electrodes having predefined relative positions adapted for treating the first workpiece, each of the virtual electrodes being in fluid communication with one of the electrode compartments;

the second virtual electrode unit being adapted to define a second set of virtual electrodes having predefined relative positions adapted for treating the second workpiece, each of the virtual electrodes of the second virtual electrode unit being adapted for fluid communication with one of the electrode compartments, relative positions of the virtual electrodes of the second field shaping unit

being different from relative positions of the virtual electrodes of the first field shaping unit; and

instructing a user to treat the first workpiece with the initial electrochemical processing chamber; to replace the first virtual electrode unit with the second virtual electrode unit, thereby modifying the initial electrochemical processing chamber by repositioning the virtual electrodes without necessity of altering the electrodes of the reaction vessel; and to treat the second workpiece with the modified electrochemical processing chamber.

14. The method of claim 13 wherein the electrode compartments in the initial electrochemical processing chamber are defined by a first plurality of walls coupled to the first virtual electrode unit and received in predefined spaces between adjacent electrodes, the first plurality of walls and the first virtual electrode unit together defining a first field shaping unit, instructing the user to replace the first field shaping unit with the second field shaping unit comprising instructing the user to remove the first field shaping unit.

15. The method of claim 14 wherein the second virtual electrode unit is coupled to a second plurality of walls, the second plurality of walls and the second virtual electrode unit together defining a second field shaping unit, instructing the user to replace the first virtual electrode unit with the second virtual electrode unit further comprising instructing the user to, after removing the first field shaping unit, place the second field shaping unit in the reaction vessel as a unit such that the walls of the second field shaping unit are positioned in the predefined spaces between adjacent electrodes.

16. The method of claim 13 wherein instructing the user to replace the first virtual electrode unit with the second virtual electrode unit comprises

instructing the user to remove the first virtual electrode unit and, thereafter, installing the second virtual electrode unit in its place.

17. The method of claim 13 wherein the reaction vessel includes a flow distributor having a separate fluid conduit in fluid communication with each of the electrode compartments and a separate annular recess for releasably receiving a lower edge of each wall, instructing the user to replace the first virtual electrode unit with the second virtual electrode unit comprising instructing the user to remove the walls of the first partition from the annular recesses of the distributor.

18. The method of claim 17 wherein instructing the user to replace the first virtual electrode unit with the second virtual electrode unit further comprises instructing the user to insert a lower edge of each of the walls of the second virtual electrode unit in one of the annular recesses in the flow distributor.

19. A method of modifying an electrochemical processing chamber from a first configuration for treating a first workpiece to a second configuration for treating a different second workpiece, the electrochemical processing chamber initially comprising a reaction vessel having an interior, an electrode positioned in the interior, and a replaceable first virtual electrode unit above the electrode, the first virtual electrode unit defining a first virtual electrode adapted for treating the first workpiece and in fluid communication with the electrode, the method comprising:

providing a second virtual electrode unit which defines a second virtual electrode adapted for treating the second workpiece;

without modifying the electrodes, removing the first virtual electrode unit from the reaction vessel; and

without modifying the electrodes, installing the second virtual electrode unit in the reaction vessel;

whereby the virtual electrode in the initial electrochemical processing chamber is moved to a different relative position defined by the second virtual electrode unit for treatment of the second workpiece without necessitating modification of the electrode.

20. A method of modifying an electrochemical processing chamber from a first configuration for treating a first workpiece to a second configuration for treating a different second workpiece, the electrochemical processing chamber initially comprising a reaction vessel and a replaceable first field shaping unit; the first field shaping unit having a plurality of concentric walls and a virtual electrode unit, the walls electrically separating a plurality of concentric electrode compartments and the virtual electrode unit defining a first set of virtual electrodes having predefined relative positions, a separate one of the virtual electrodes being in fluid communication with each of the electrode compartments; the reaction vessel comprising a wall defining an interior, the interior receiving the walls of the first field shaping unit and a plurality of electrodes, at least one of the electrodes being positioned in each of the electrode compartments, adjacent electrodes being spaced from one another to define predefined spaces within which the walls are received; the method comprising:

providing a second field shaping unit having a plurality of concentric walls and a second virtual electrode unit, the second virtual electrode unit defining a second set of virtual electrodes having predetermined relative positions adapted for treating the second workpiece, the relative positions

of the virtual electrodes in the second set differing from the relative positions of the virtual electrodes in the first set;

without modifying the electrodes, removing the first field shaping unit from the reaction vessel as a unit; and

without modifying the electrodes, installing the second field shaping unit in the reaction vessel as a unit, the walls of the second field shaping unit being received in the predefined spaces between the electrodes;

whereby the virtual electrodes in the initial electrochemical processing chamber are moved to new relative positions defined by the second virtual electrode unit for treatment of the second workpiece without necessitating modification of the electrodes.

21. An electrochemical processing chamber, comprising:

a reaction vessel having an interior;

an electrode received in the interior of the reaction vessel; and

a first virtual electrode unit comprising a dielectric material and defining a first virtual electrode in fluid communication with the electrode, the first virtual electrode unit being exchangeable for a second virtual electrode unit, without necessitating modification of the electrode, to adapt the processing chamber for treating a differently-sized workpiece.

22. An electrochemical processing chamber, comprising:

a reaction vessel having an inner surface;

a first wall spaced from the inner surface of the reaction vessel, the first wall being formed of a dielectric material and electrically separating a first electrode compartment from a second electrode compartment;

a first electrode positioned in the first electrode compartment and a second electrode positioned in the second electrode compartment; and

a first virtual electrode unit comprising a dielectric material and defining a first virtual electrode in fluid communication with the first electrode compartment, the first partition also defining, in part, a second virtual electrode in fluid communication with the outer electrode compartment, the first virtual electrode unit being exchangeable for a second virtual electrode unit, without necessitating modification of the electrodes, to adapt the processing chamber for treating a differently-sized workpiece.

23. The electrochemical processing chamber of claim 22 wherein the first virtual electrode unit comprises a first partition having a first section extending radially inwardly from the first wall and a lip defining a circular opening.

24. The electrochemical processing chamber of claim 22 wherein the first wall is carried by the first virtual electrode unit and is removable therewith as a unit when exchanging the first virtual electrode unit for the second virtual electrode unit.

25. The electrochemical processing chamber of claim 22 further comprising a flow distributor having a first fluid outlet associated with the first electrode compartment and a second fluid outlet associated with the second electrode compartment.

26. The electrochemical processing chamber of claim 25 wherein the first wall is carried by the first virtual electrode unit and the first wall has a lower edge releasably received in an annular recess in the flow distributor positioned between the first fluid outlet and the second fluid outlet.

27. The electrochemical processing chamber of claim 22 wherein the first virtual electrode comprises a central discharge opening through which fluid may flow.

28. The electrochemical processing chamber of claim 27 wherein the first virtual electrode receives an electrical potential via flow of an electrically conductive fluid over the first electrode and upwardly through the first virtual electrode.

29. The electrochemical processing chamber of claim 27 wherein the second virtual electrode comprises an annular opening through which fluid may flow.

30. The electrochemical processing chamber of claim 29 wherein the second virtual electrode receives an electrical potential via flow of an electrically conductive fluid over the second electrode and upwardly through the second virtual electrode.

31. The electrochemical processing chamber of claim 22 wherein the first virtual electrode receives a first electrical potential from the first electrode.

32. The electrochemical processing chamber of claim 31 wherein the second virtual electrode receives a second electrical potential from the second electrode.

33. The electrochemical processing chamber of claim 22 wherein the electrodes are anodes.

34. An electrochemical processing chamber, comprising:

a plurality of concentric walls defining a plurality of concentric annular electrode compartments, the walls being formed of a dielectric material;

a plurality of electrodes, each of the electrode compartments having at least one of the electrodes positioned therein;

a fluid distributor having a plurality of fluid channels, each of the electrode compartments being in fluid communication with at least one of the fluid channels; and

a first virtual electrode unit formed of a dielectric material, the first virtual electrode unit defining a plurality of flow conduits, with at least one of the flow conduits being in fluid communication with each of the electrode compartments, the first virtual electrode unit being exchangeable for a second virtual electrode unit, without modification of any of the electrodes, to adapt the processing chamber for treating a differently-sized workpiece.

35. The electrochemical processing chamber of claim 34 wherein the walls are coupled to the first virtual electrode unit and can be removed therewith as a unit.

36. The electrochemical processing chamber of claim 34 wherein the walls are carried by the fluid distributor and remain attached thereto when the virtual electrode unit is removed.

37. The electrochemical processing chamber of claim 34 wherein the virtual electrode unit comprises a plurality of partitions, with one partition being associated with each of the walls.

38. The electrochemical processing chamber of claim 37 wherein the plurality of partitions are joined to one another such that the virtual electrode unit may be exchanged as a unit.

39. The electrochemical processing chamber of claim 34 further comprising a second virtual electrode unit exchangeable for the first virtual electrode unit, each of the first and second virtual electrode units being adapted to adjoin the walls at the same radial distances from a center line of the processing chamber.

40. The electrochemical processing chamber of claim 34 an inner one of the flow conduits of the first virtual electrode unit defines a central discharge opening and each of the other flow conduits of the first virtual electrode unit defines concentric annular discharge openings.

41. The electrochemical processing chamber of claim 40 wherein each of the flow conduits defines a separately controllable virtual electrode.

42. The electrochemical processing chamber of claim 34 wherein each of the flow conduits defines a separately controllable virtual electrode.

43. The electrochemical processing chamber of claim 34 wherein the first virtual electrode unit comprises a plurality of partitions, each partition being having a first section and a lip, the first section being coupled to one of the walls and extending radially inwardly therefrom, the lip defining a circular opening.

44. The electrochemical processing chamber of claim 34 further comprising a flow distributor having a plurality of fluid conduits, with one fluid conduit being in fluid communication with each of the electrode compartments.

45. The electrochemical processing chamber of claim 44 wherein the walls are carried by the first virtual electrode unit and each of the walls has a lower edge releasably received in a separate annular recess in the flow distributor.

46. An electrochemical processing chamber, comprising:

a reaction vessel comprising:

a vessel wall defining an interior of the reaction vessel; and

first and second electrodes, the first electrode being spaced radially inwardly of the second electrode; and

a replaceable field shaping unit comprising:

a first wall removably received in the interior of the reaction vessel, the first wall being formed of a dielectric material and electrically separating a first electrode compartment from a second electrode compartment, the first electrode being positioned within the first electrode compartment and the second electrode being positioned within the second electrode compartment;

a virtual electrode unit comprising a first partition formed of a dielectric material and coupled to the first wall, the first partition defining a first virtual electrode in fluid communication with the first electrode compartment and defining, in part, a second virtual electrode in fluid communication with the second electrode compartment;

the replaceable field shaping unit being removable from the reaction vessel as a unit without necessitating modification of the reaction vessel.

47. The electrochemical processing chamber of claim 46 wherein the reaction vessel has an outer wall with an upper edge, an outer portion of the virtual electrode unit engaging the upper edge of the outer wall in defining the second electrode compartment.

48. An electrochemical processing chamber, comprising:

a replaceable first field shaping unit comprising:

a plurality of concentric walls electrically separating a plurality of concentric electrode compartments; and

a virtual electrode unit comprising a plurality of partitions, each of the walls having a separate partition coupled thereto, the virtual electrode unit defining a plurality of virtual electrodes, with a separate virtual electrode in fluid communication with each of the electrode compartments; and

a reaction vessel comprising:

a vessel wall defining an interior receiving the walls of the first replaceable field shaping unit; and

a plurality of electrodes, at least one of the electrodes being positioned in each of the electrode compartments;

the replaceable first field shaping unit being removable from the reaction vessel as a unit for replacement with a second field shaping unit, without necessitating modification of any of the plurality of electrodes, to adapt the electrochemical processing chamber for use with a differently-sized workpiece.

49. The electrochemical processing chamber of claim 48 wherein the second field shaping unit comprises:

a plurality of concentric walls adapted to electrically separate a plurality of concentric electrode compartments when the plurality of walls is installed in the interior of the reaction vessel; and

a virtual electrode unit comprising a plurality of partitions, each of the walls having a separate partition coupled thereto, the virtual electrode unit defining a plurality of virtual electrodes, with a separate virtual electrode in fluid communication with each of the electrode compartments when the second field shaping unit replaces the first field shaping unit;

a relative arrangement of the virtual electrodes of the second replaceable field shaping unit being different from a relative arrangement of the virtual electrodes of the first field shaping unit, thereby facilitating adaptation of the electrochemical processing chamber for use with the differently-sized workpiece.

50. The electrochemical processing chamber of claim 48 further comprising a flow distributor having a plurality of fluid conduits, with one fluid conduit being in fluid communication with each of the electrode compartments.

51. The electrochemical processing chamber of claim 50 wherein each of the walls has a lower edge releasably received in a separate annular recess in the flow distributor.

52. An electrochemical processing system, comprising:

a reaction vessel having an outer wall and a plurality of concentric, annular electrodes, adjacent electrodes being spaced from one another to define annular wall-receiving spaces therebetween;

a replaceable first field shaping unit comprising:

a plurality of concentric walls formed of a dielectric material and having upper edges, the walls being positioned with respect to one another to be received in the wall-receiving spaces between the electrodes to define a plurality of concentric electrode compartments with at least one of the electrodes being received within each of the electrode compartments; and

a first virtual electrode unit formed of a dielectric material and coupled to the walls adjacent their upper edges, the first virtual electrode unit being adapted to abut the outer wall of the reaction vessel, the first virtual electrode unit defining a first set of discharge openings having predefined relative positions, each of the discharge openings of the first set being adapted for fluid communication with one of the electrode compartments, each discharge opening of the first set defining a position of a virtual electrode; and

a replaceable second field shaping unit comprising:

a plurality of concentric walls formed of a dielectric material and having upper edges, the walls being positioned with respect to one another to be received in the wall-receiving spaces between the electrodes to define a plurality of concentric electrode compartments with at least one of the electrodes being received within each of the electrode compartments; and

a second virtual electrode unit formed of a dielectric material and coupled to the walls adjacent their upper edges, the second virtual

electrode unit being adapted to abut the outer wall of the reaction vessel, the second virtual electrode unit defining a second set of discharge openings having predefined relative positions, the relative positions of the discharge openings of the second set differing from the relative positions of the discharge openings of the first set, each of the discharge openings of the second set being adapted for fluid communication with one of the electrode compartments, each discharge opening of the second set defining a position of an virtual electrode;

the first field shaping unit and the second field shaping unit each being adapted for installation in and removal from the reaction vessel as a unit.

53. The electrochemical processing chamber of claim 52 wherein the reaction vessel further comprises a flow distributor adapted to deliver processing fluid to each of the electrode compartments defined when the first field shaping unit or the second field shaping unit is installed in the reaction vessel.

54. The electrochemical processing chamber of claim 53 wherein the flow distributor includes a plurality of spaced-apart annular recesses, each of the walls of each of the field shaping units having a lower edge sized to be releasably received in one of the annular recesses when the field shaping unit is installed in the reaction vessel.

55. The electrochemical processing chamber of claim 53 further comprising a first contact assembly adapted to support a first workpiece above the electrodes in a predefined position with respect to the virtual electrodes of the first field shaping unit.

56. The electrochemical processing chamber of claim 55 further comprising a second contact assembly adapted to support a second workpiece above the electrodes in a predefined position with respect to the virtual electrodes of the second field shaping unit.

57. An electrochemical processing chamber, comprising:

a reaction vessel having an interior;

an electrode received in the interior of the reaction vessel;

a first virtual electrode unit comprising a dielectric material and defining a first virtual electrode in fluid communication with the electrode; and

a first contact assembly adapted to support workpiece in a predetermined position with respect to the first virtual electrode;

the first contact assembly being exchangeable for a second contact assembly and the first virtual electrode unit being exchangeable for a second virtual electrode unit, without necessitating modification of the electrode, to adapt the processing chamber for treating a differently-sized workpiece.